California Environmental Protection Agency

AIR RESOURCES BOARD

AIR QUALITY SURVEILLANCE BRANCH

STANDARD OPERATING PROCEDURES

FOR

MET-ONE INSTRUMENTS
BETA ATTENUATION MASS MONITOR
(BAM-1020)

AQSB SOP 400

First Edition

MONITORING AND LABORATORY DIVISION

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California Environmental Protection Agency
AIR RESOURCES BOARD

Approval of Standard Operating Procedures (SOP)

Title: Met One Instruments Beta Attenuation Mass Monitor (BAM-1020)

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Section: Operation Support Section

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1.0 GENERAL INFORMATION

1.1 Introduction:

The purpose of this Standard Operating Procedure (SOP) is to document the Met One Beta Attenuation Mass Monitor, model 1020 (BAM-1020) procedures used by the Air Quality Surveillance Branch of the California Air Resources Board (ARB). The goal of this SOP is two fold; to formalize BAM-1020 installation, configuration and operation procedures in order to ensure comparability among all BAM-1020 data, and to describe supplemental information and modifications to the Met One BAM-1020 Operation Manual necessary to successfully integrate the BAM-1020 into California's ambient air monitoring network. The Met One Instrument's BAM-1020 Operation Manual contains a significant source of information pertinent to the operation, maintenance and understanding of this instrument, and therefore the ARB highly recommends a thorough review of the BAM-1020 Operation Manual.

1.2 Principle of Operation:

The BAM-1020 measures and records hourly particulate mass concentrations in ambient air. The monitor consists of three basic components; the central unit, the sampling pump and the sampling inlet hardware. Each component is self-contained and may be easily disconnected for servicing and replacement.

The BAM-1020 uses beta ray attenuation to calculate collected particle mass concentrations in units of ug/m3. A ^{14}C element (60 μCi +/- 15 μC) emits a constant source of low-energy electrons, also known as beta particles. The beta rays are attenuated as they collide with particles collected on a filter tape. The decrease in signal detected by the BAM-1020 scintillation counter is inversely proportional to the mass loading on the filter tape.

1.3 Safety Precautions:

Only properly trained personnel should perform BAM-1020 testing, installation, operation, maintenance and calibration procedures. As with all monitoring equipment, precautions should be taken when working around electricity, power tools and above ground elevations.

The ^{14}C radioactive source should never be dismantled, removed or tampered with. It will never be necessary for any field personnel to adjust, replace or touch the ^{14}C source. All ^{14}C issues will be handled by the manufacturer either under warrantee or at ARB cost. When working with the BAM-1020 door open and in the immediate vicinity of the ^{14}C beta source, the wearing of long sleeves and laboratory gloves may help reduce possible exposure to ^{14}C beta rays.

The US EPA Code of Federal Regulations (CFR) and the Code of California Regulations (CCR) allows no more than ten (10) BAM-1020 units at any one facility at one time. There are NO restrictions or special requirements (such as licenses or permits) to ship, receive or operate a BAM-1020 monitor within the State of California.

1.4 Interferences/Limitations:

Moisture: The Met One BAM-1020 is a mass analyzer, and therefore any component that is suspended on the filter tape and attenuates beta rays will subsequently affect the average mass value for that hour. Moisture in the ambient air can affect both monitor performance and hourly average mass values. An inlet heater is essential for most BAM-1020 applications through out the State of California. The Met One BAM-1020 should include one of two types of inlet heaters; a heat tape kit and the Smart heater kit.

The heat tape: The initial configuration of the ARB BAM-1020 monitor included an inlet heat tape kit. This kit contained a 30 Watt heater tape, a grey colored control box and all required accessories. In theory, the grey control box activates the inlet heat tape when the internal relative humidity sensor detected a moisture content at or above 55% RH. The heat applied to the inlet tube from the heater tape increases the inlet air stream approximately 3 to 5 ^{O}C above the ambient air temperature. The slight elevation in temperature should help prevent inlet air moisture from condensing on the filter tape. The internal inlet %RH sensor is only used as a triggering device and should not be used or confused with external %RH data. After evaluation of the heat tape kit in the ARB continuous monitoring network, it was noticed that the heat tape was not activating even though the ambient humidity content reached 100% RH. To remedy this problem, **the heat tape no longer utilizes the grey control box and is plugged directly into a live AC outlet**.

The Smart Heater: The Smart Heater resembles a small aluminum can, rated at 200 Watts and is installed in lieu of the heater tape. The Smart Heater requires specific firmware, hard cards and other configurations to operate properly. A heat tape can easily replace a Smart Heater, but a Smart heater cannot simply replace a heat tape without additional parts and extensive modifications. Unlike the inlet heat tape kit, the Smart Heater is controlled using both %RH and temperature. These set points can be adjusted using the BAM-1020 firmware.

Reference Membrane: The reference membrane values generated during each hourly cycle are instrument drift values, not to be confused with span values. The Met One ARB BAM-1020 monitors include an eighty percent full scale reference membrane (approximately .800 mg/cm^2). Each ARB BAM-1020 monitor is deployed with a Met One BAM-1020 Operation Manual that is unique to that instrument. Appendix B of the BAM-1020 manual lists the calibration and membrane values specific to the serial number of the instrument indicated. The density of the reference membrane for the BAM-1020 is listed on the line labeled

“ABS”, a value typically between 0.800 to 0.850 mg/cm2. Each hour, this membrane is automatically positioned in the beta path and analyzed for instrument drift. The analysis of this membrane is integrated and displayed on the BAM-1020 display screen as “LAST m:” during the following hour. The “LAST m:” value should not be used or confused with instrument span values. The BAM-1020 does not have the capability to analyze or report any span value information. Factory default settings should flag any hourly mass data when the “LAST m:” value differs more than +/- 5% from expected. If the "Last m:" value is less than 0.5% from the expected "ABS" number, it is an indication that the analytical aspects of the BAM-1020 are working properly.

Power Supply: The BAM-1020 pump requires a standard external 120 VAC outlet. Plugging the BAM-1020 pump into the same power source as the BAM-1020 monitor may help reduce potential problems. If the BAM-1020 monitor is in normal sampling operation mode, a flow of 16.7 LPM is expected. If the BAM-1020 pump fails to operate during the sampling period, the monitor will acknowledge a flow error. Flow errors can be difficult for an operator to detect and the BAM-1020 can not pin point the fault. Therefore, do NOT plug only the BAM-1020 monitor into an uninterruptible power supply (UPS). Plug in both the pump and monitor into an UPS, or neither. The BAM-1020 is designed to resume normal operation after any power failure. There is not enough information at this time to determine whether using an UPS with a BAM-1020 is significantly beneficial.

Grounding and Surge Protection: A 'good' station ground and an adequate surge protector are highly recommended with all monitoring equipment, and are especially significant for proper operation of the BAM-1020. A poor or absent BAM-1020 chassis ground and/or surge protection can cause temporary or permanent damage to the BAM-1020 monitor. Using an UPS will not provide a chassis ground and most likely will not provide adequate surge protection.

The inlet tube should also be grounded to the BAM-1020 chassis. To ground the inlet tube, be sure to firmly tighten the two hexagonal head screws to the inlet tube. The two hexagonal head screws are located at the top inlet connection area of the BAM-1020 monitor.

2.0 INSTALLATION PROCEDURE

The BAM-1020 Installation procedure has been separated into the following ten (10) areas. Each area is described in further detail.

1) List of tools/supplies.
2) Physical Inspection.
3) Siting.
4) Installing BAM-1020 Central Unit.
5) Drilling Inlet Tube Hole.
6) Attaching Inlet Support Hardware.
7) Tape Loading.
8) Pump Connection.
9) Outside Temperature (OT) Connection.
10) ESC 8800 / ESC 8816 Data Logger Connection.

2.1 List of Tools/Supplies:

1) Hole saw/bits (1 3/8" and 2 1/4").
2) Weather proof silicon or roof sealant.
3) 2 conductor cable (min. AWG 20 gauge).
4) Tape (i.e. Scotch or masking).
5) 4 lag screws adequate for roof mounting plate.
6) Rack mounting screws.
7) Tools that include drill, screwdriver and socket set.
8) Certified flow standard capable of measuring 16.7 LPM.
9) Certified temperature and pressure standard.

2.2 Physical Inspection:

Upon receipt of a BAM-1020, inspect equipment and accessories for completeness and for shipping damage. If shortage or damage is found, immediately notify your supervisor, and/or your agency's shipping department.

NOTE: The BAM-1020 should never be moved unless the two hard foam packing rings (referred to as donuts) are placed around the transport rollers. Failure to install the donuts can cause severe damage to the tape advance mechanism.

List of BAM-1020 Components:

1) BAM-1020 central unit.
2) Vacuum pump.
3) Inlet Tubing.
4) PM10 FRM Inlet.
5) PM2.5 Sharp Cut Cyclone (SCC) Inlet.
6) Heater Kit.
7) Inlet Support Brackets.
8) Pump tubing and wiring.
9) Outside Temperature Sensor.

2.3 Siting:

The BAM-1020 monitor has specific physical requirements that should be considered prior to installation. In addition, all ARB BAM-1020 monitors (PM2.5, PM10 and TSP), should be deployed using 40 CFR 58 PM2.5 requirements to ensure data continuity. The BAM-1020 central unit and pump is neither waterproof nor water-resistant and must be protected from moisture. The BAM-1020 was designed to operate in a temperature-controlled enclosure (between 0 °C and 40 °C), and where the relative humidity is not condensing and does not exceed 90 percent. All ARB BAM-1020 monitors will be deployed inside a weather proof and temperature controlled structure. The effort towards maintaining a consistent temperature for the BAM-1020 throughout each day is to ensure a baseline quality database by limiting the number of unknown variables that may exist within California's Ambient Monitoring Network.

In general, when choosing the location for BAM-1020 monitor, it may help to consider the following items:

1) Inlet radius clearance: The BAM-1020 inlet must have a one (1) meter radius free of any objects that may influence airflow characteristics, including the airflow radius of another instrument. For example, if a BAM-1020 is to be installed at a station with another BAM-1020 or a PM2.5 FRM filter sampler, the inlets of each sampler must be no less than 2 meters apart from each other. If installing near a PM10 SSI HiVol sampler, then the distance between the inlets of the BAM-1020 and the HiVol must be no less than three (3) meters. These distances are Federal EPA requirements (40 CFR Part 58), and are designed to limit inlet airflow interference.

2) Inlet height: The height of the inlet should be equal to the height of the federal reference method filter samplers such as the PM10 inlet on the PM2.5 FRM or the large round PM10 impactor on the SSI HiVol.

3) Distance between BAM-1020 and station ceiling: A minimum distance of at least eight (8) inches is required between the top of the BAM-1020 and ceiling. This distance is necessary to safely accommodate any of the two types of inlet heaters.

4) Heater Kit: The two types of inlet heaters are the heat tape or a Smart Heater. The heat tape wraps around the lower end of the inlet tube (inside the station). The Smart Heater resembles a small aluminum can and replaces the heat tape. When installed, either heating device should be located around the lower end of the inlet tube, just where the BAM-1020 and the inlet tube intersect (about 0.5 to 1.0" above). Either heating device will cover approximately four (4) inches in length of the inlet tube. The heating device should be a minimum of two (2) inches away from any object, such as the instrument rack or ceiling. A minimum distance between the top surface of the BAM-1020 central unit and the ceiling should be NO LESS than ten (10) inches.

5) Inlet: The straight, vertical inlet tubing of the BAM-1020 limits the placement of the BAM-1020 central unit. The BAM-1020 inlet tubing is a 1 5/16” OD, 8’ long rigid aluminum tube. The lower end of the inlet tube inserts directly into the top of the BAM-1020 housing, the other end points vertically upward through all roofing material and above the roofline. The selected particle size inlet(s) are mounted on the upper end of the inlet tube. The BAM-1020 FRM PM10 head should be installed so that its height is equal the same inlet height of the PM2.5 FRM or HiVol SSI filter sampler heads (approximately six (6) feet above the roof line). Provisions must be made during installation to allow future removal, maintenance and re-installation of all equipment.

   Total inlet tube length should not exceed more than sixteen (16) feet (two 8' lengths with coupling).

6) Specifications: Specifications for siting a BAM-1020 will mirror the Federal EPA PM2.5 criteria listed in the Code of Federal Regulations (40 CFR, Part 58).

2.4 Installing BAM-1020 Central Unit:

The BAM-1020 can be rack mounted, placed on a table, shelf or other flat surface. As with all instrumentation installations, the racks, table or fixture must be secure and the overall installation must protect both the instrument and personnel.

Because the BAM-1020 connector fitting for the inlet tube is located on top of the BAM-1020 central unit, installation of the BAM-1020 does not allow for other instruments to be mounted above it. Wherever the BAM-1020 is installed, space for the vertical position of the inlet tube, inlet hardware and heater must be taken into account.

2.5 Drilling Inlet Tube Hole:

Applications may vary due to structural and material makeup. Forethought may help alleviate problems and frustration. After locating a suitable place for the BAM-1020 monitor, the holes for the BAM inlet tube can be drilled. Protect instruments from falling debris. The inlet support hardware includes a rooftop mounting plate for stations with a flat roof. The mounting plate has a circular ridge that protrudes beneath the surface and therefore a 2¼" diameter recess must be made on top of the roof in order to accommodate the ridge.

Inside station ceiling hole: The hole on the inside of the station should only be large enough to accommodate the outside diameter of the inlet tube. Use a 1 3/8" diameter hole saw. A plumb bob can help locate the best position on the ceiling of air monitoring stations. Drill a 1 3/8" hole vertically through the ceiling DIRECTLY ABOVE the BAM-1020 monitor inlet spout. STOP drilling when the tip of the guide bit just begins to poke through the top of the roof. The drill bit hole will be used as a guide when drilling from above and therefore do NOT drill a 1 3/8" hole all the way through the roof.

Outside roof top hole: Relocate to the topside of the roof after drilling the 1 3/8" inside ceiling hole from underneath (remember to only drill until the hole saw bit just pokes through the roof top). Using the hole created by the guide drill of the 1 3/8" hole saw bit, drill downward with a 2¼" hole saw until the hole is deep enough to accommodate the roof mounting plate.

2.6 Attaching Inlet Support Hardware:

Affix the inlet mounting plate to the top of the roof with plenty of weatherproof sealant and four adequate lag bolts. Attach the supplied inlet coupler to the mounting plate. Slide the inlet tube through the coupler, plate, roof and ceiling. From inside the station, gently insert and seat the bottom end of the inlet tube into the top of the BAM-1020 central unit. Leak test sealing of the roof jack with water. Two (2) additional lag screws, the two supplied inlet brackets and the single (1) supplied hose clamp can be used to help support the inlet tube. The inlet(s) can now be attached to the top end of the inlet tube. Be sure to firmly tighten both BAM-1020 hexagonal inlet screws to the inlet tube.

2.7 Tape Loading: Refer to Figure 1 (below), for photo of installed filter tape.

Loading the tape must be performed before accessing other BAM-1020 functions. Begin by lifting the pinch roller (the pin with the black roller located in

the upper front of the BAM) and lock the roller into position with the latch (located immediately to the left of the pinch roller). Remove both clear spool caps by unscrewing the black knobs (bottom left and bottom right spools). Unroll approximately 2 to 3 feet of tape and slide the roll on to the bottom right spool (supply spool) of the BAM-1020. Position of the supply spool so that as the tape unwinds on the spool, the roll turns counter clockwise. The tape will 'S' around the two center rollers by feeding around the left supply tension roller located just above and to the left of the supply spool, then around the right side of the right end roller located slightly above and to the right of the tension roller. The tape slides in the slit located between the source and detector, and between the pinch roller and capstan shaft (the thin metal shaft located just below the pinch roller). 'S' the tape around the left side of the left end roller (roller on the upper left), around the right side of the take-up tension roller (just below and to the right), then tape onto to the take-up spool (located bottom left). Wrap the tape approximately 1½ times around the take-up spool. The left side tape configuration should be a mirror image of the right side.

Lift up on the pinch roller (the latch will automatically unlock). Gently lower the pinch roller until it completely touches the filter tape against the capstan roller. Visually check tape for binding, tears or other obvious problems. Wherever the tape comes in contact with the rollers, the entire width of the tape should be on the roller with a little bit of the roller's edge showing. **It is highly recommended to perform a 'SELF TEST' following the BAM-1020 installation, after routine filter tape change, when troubleshooting and after correcting any problem**.

The BAM-1020 'SELF TEST' is performed by the following steps:

1. In the BAM-1020 main menu, press the "**TAPE**" soft key.

2. Next, press the "**SELF TEST**" soft key.

3. If all BAM-1020 checks pass, the display will read 'Status: SELF TEST PASSED'. If the display reads 'FAILED', remedy the problem and rerun 'SELF TEST'. Most likely, the condition that caused the 'SELF TEST' failure will be indicated on the display.

4. At the completion of the BAM-1020 'SELF TEST', press the "**EXIT**" soft key to return to the main menu. The BAM-1020 tape is now loaded and adjusted. Figure 1 picture below represents a properly loaded BAM-1020 filter tape.

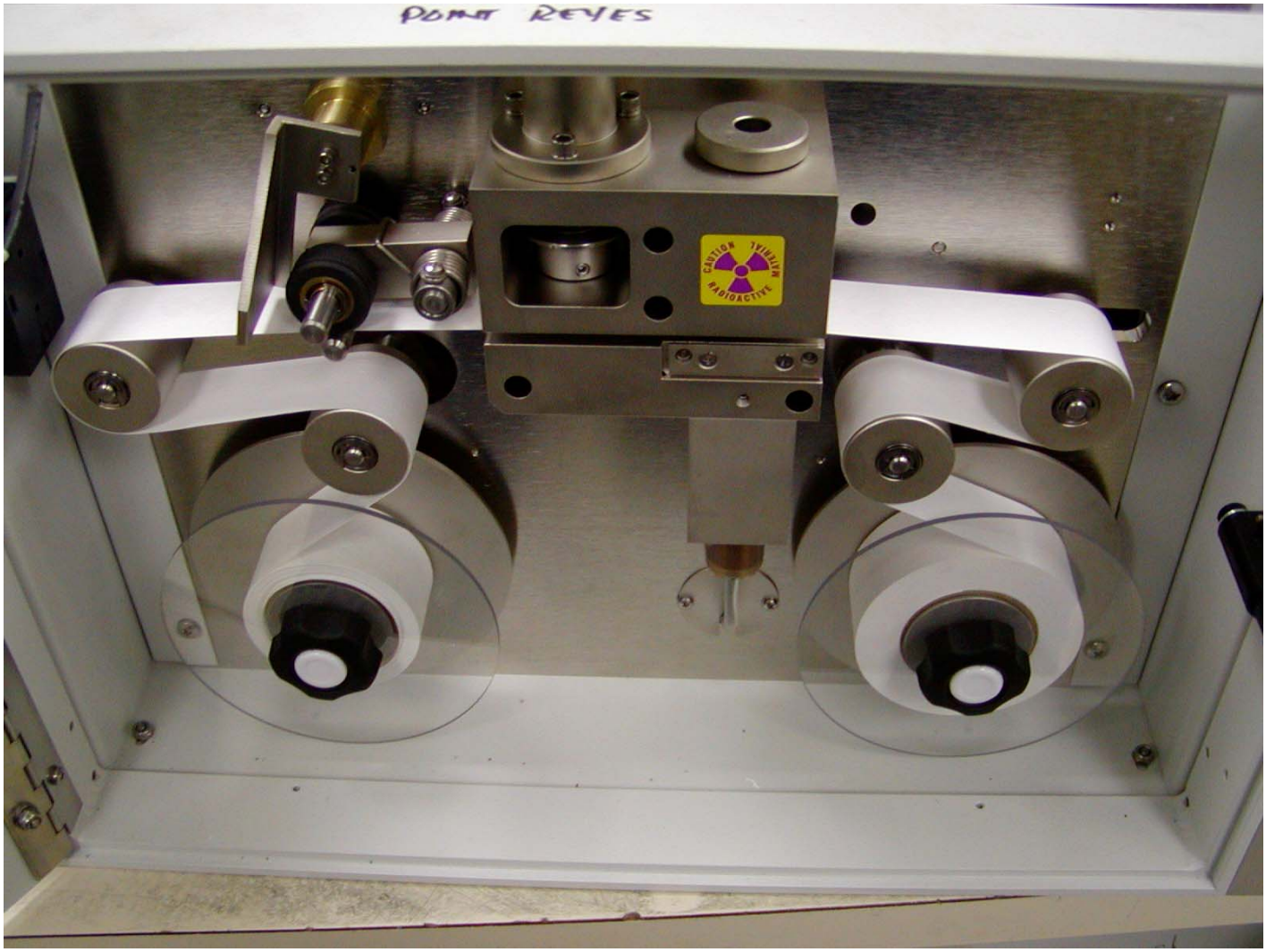

FIGURE 1 – Picture of Loaded Filter Tape

2.8 Pump Connection: The pump connects to the BAM-1020 with the supplied clear vacuum tube and 2-lead wire.

Pump tubing: Insert one end of the supplied clear tubing to the only flow 'inlet' connector of the pump, and the other end of the tubing to the only tube connector located to the lower rear of the BAM unit. Push in each end of the tubing all the way in, then pull back slightly to ensure a good seal. The tubing should remain at least 6 feet in length to help reduce any possibly flow fluctuations caused by the pump.

Pump wiring: Refer to Figure 2 (page 17). Attach one end of the supplied 2 lead wire to the two inside terminals on the pump, the other end to the terminals on the rear of the BAM unit labeled 'PUMP CONTROL'.

2.9 Outside Temperature (OT) Connection: Refer to Figure 3 (page 18).

All ARB deployed BAM-1020 monitors will be configured for volumetric flow control. This will require the installation of either the supplied OT sensor or the existing station OT sensor. The BAM-1020 OT out can be connected to either the ESC 8800 or 8816 data logger. The BAM-1020 OT sensor must be calibrated prior to the BAM-1020 monitor flow calibration.

Connect the OT thermister cable wires to the orange input blocks on the BX-964 translator located behind the tan plate on the back of the BAM. Attach the OT sensor leads to connectors 7 and 8 by the block labeled "INPUTS CH3".

2.10 ESC **8800 / 8816** Data Logger Connection:

ESC 8800 data logger connection: When using an ESC 8800 data logger, two separate data logger channels are required; one channel for data collection and one channel for contact closure control.

A) Data channel connection: Refer to Figure 2 (page 17). Attach one end of a shielded 2 wire cable (not supplied) to the (+) and (-) connectors at rear of the BAM-1020 labeled 'VOLT OUT'. Attach the other end of the (+) lead to the ESC 8800 "Analog In" channel 6. Attach the other end of the (-) lead to the ESC 8800 'Analog In' 'GND'.

B) Contact closure channel connection: Refer to Figure 2(page 17). A contact closure connection is required to sync the BAM-1020 clock with the ESC 8800 data logger. The importance of syncing the two clocks together is limited to the tight time frame in which BAM-1020 data is available and the necessity of the ESC data logger collected it before the sampling hour is ended.

Attach one end of a shielded 2-wire cable (not supplied) to the connectors at rear of the BAM monitor labeled ‘EXT RESET N.V.’. Attach the other end of the 2 lead wire to the ESC 8800 channel 6 “Digital Out”.

ESC 8816 data logger connection: When using an ESC 8816 data logger, two separate data logger channels are also required, though the configurations are quite different than the ESC 8800 configuration. One channel is configured as the raw BAM-1020 input and the other is configured for a math averaging function. The ESC 8816 contact closure commands are independent of channel configurations. A hard wire connection must be installed for the BAM-1020 raw data and the clock contact closure function. No hard wiring is necessary for the 'math averaging' channel.

A) Raw data channel connection: Attach one end of a shielded 2 wire cable (not-supplied) to the (+) and (-) connectors at rear of the BAM monitor labeled ‘VOLT OUT’. Attach the other end of the (+) and (-) lead to the ESC 8816 “Analog In” channel 32.

B) Contact closure channel connection: A contact closure connection is required to sync the BAM monitor clock with the ESC 8816 data logger. Again, the importance of syncing the two clocks together is limited to the tight time frame in which BAM-1020 data is available and the necessity of the ESC data logger collected it before the sampling hour is ended.

Attach one end of a shielded 2-wire cable (not supplied) to the connectors at rear of the BAM monitor labeled ‘EXT RESET N.V.’. Attach the other end of the 2-wire cable to the ESC 8816 channel 6 “Digital Out”.

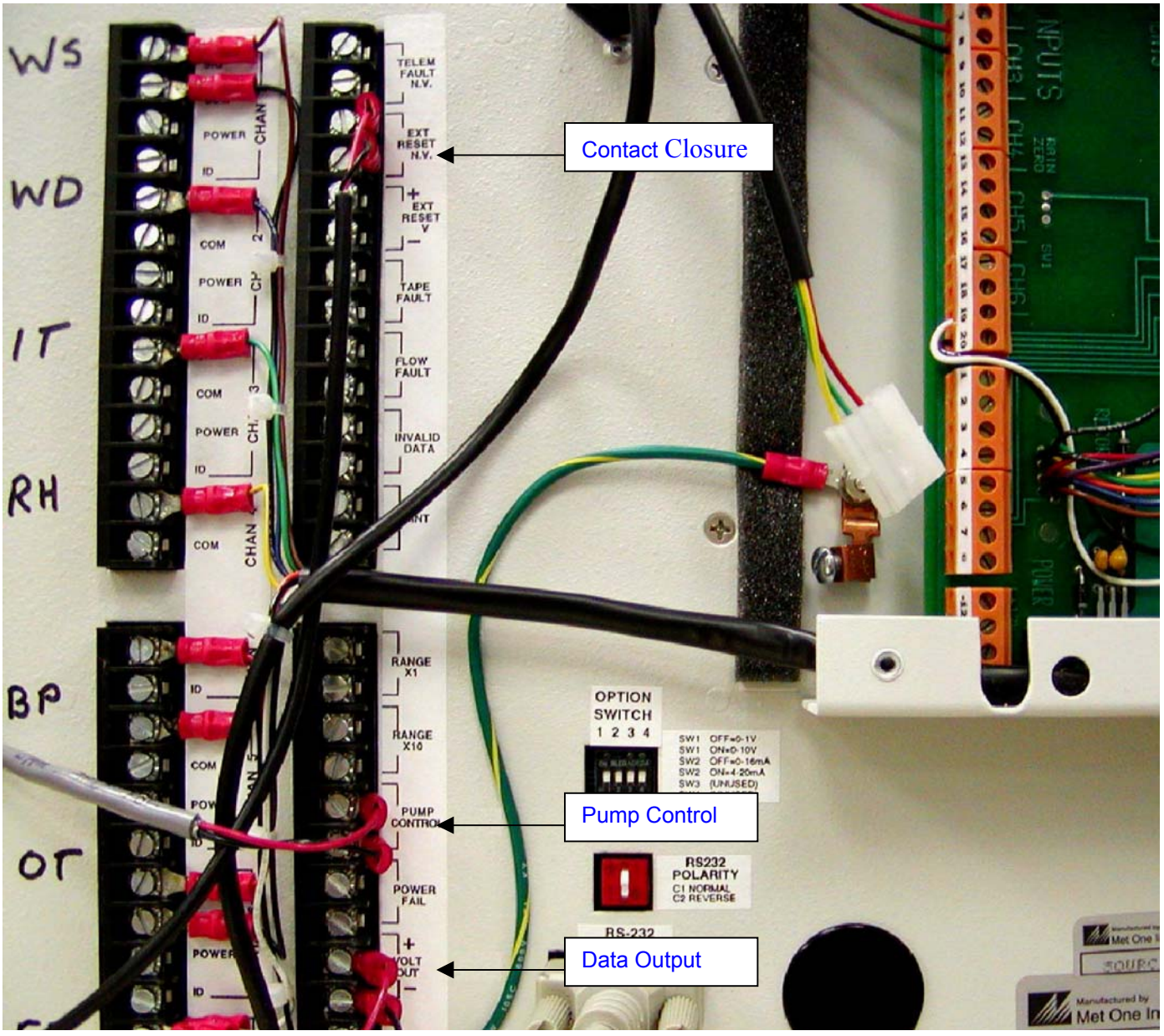

FIGURE 2 – Data Logger / Pump Connection (rear view of BAM-1020)

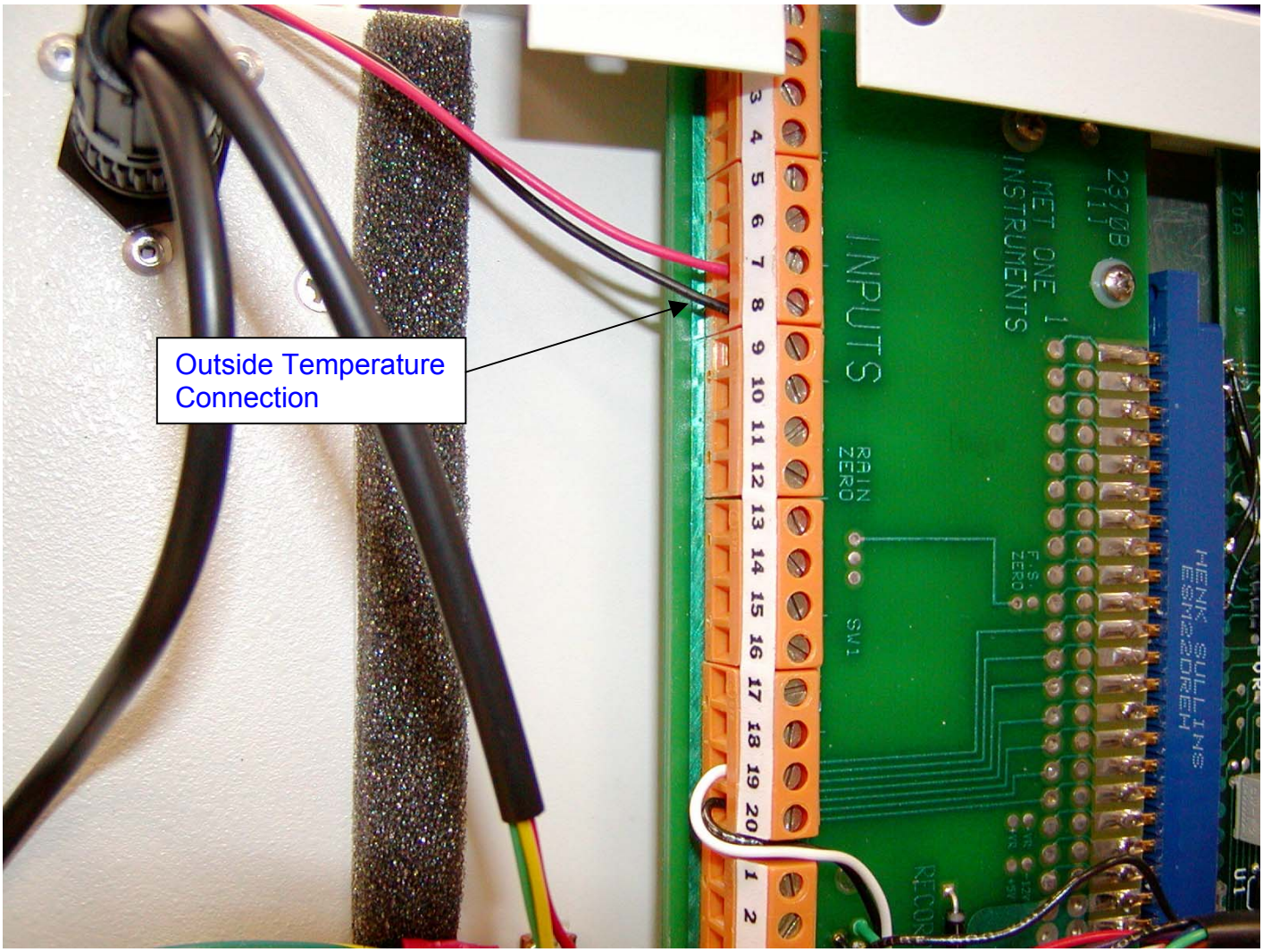

FIGURE 3 – Outside Temperature (OT) Wire Connection (with met cover removed)

3.0 CONFIGURATION

3.1 Configure BAM-1020: Each BAM-1020 is calibrated at the factory and therefore has unique calibration settings. The correct settings for BAM-1020 are located in Appendix B of the BAM-1020 Operation Manual.

As with any instrument, it is always important to exit out to the main menu and return back to check if the changes were in fact saved. If changes in the configuration have not been saved, the cause is often due to a configuration parameter that is out of the BAM-1020 operating range or a value that is significantly different than the current operating conditions.

When configuring or calibrating the BAM-1020, it is important to exit out to the main menu before proceeding to the next parameter. This will ensure that each change has been saved and that the BAM-1020 has updated it's memory to the new configuration or set point. The BAM-1020 is in the main menu when the bottom of the display reads the words "SETUP", "OPERATE", "TEST" and "TAPE".

Clock Set: When setting up the BAM-1020, it is crucial that the BAM-1020 clock is set to the ESC data logger clock (within 30 seconds). If the clocks are not set to within 30 seconds of each other, then the clock syncing program will not work and the data will be flagged. To set the clock:

1) Press the "**SETUP**" soft key.

2) Ensure that the cursor is in the word 'CLOCK and press the "**SELECT**" soft key.

3) Use the cursor arrows to adjust the BAM-1020 date and time.

4) Press the "**SAVE**" soft key.

5) Press the "**EXIT**" soft key.

6) Confirm BAM-1020 date and time display in main menu.

Early Cycle Mode: There are two different configurations for the BAM-1020 analog output; the 'Standard' mode and the 'Early' cycle mode. To configure the BAM-1020 so that either type of ESC data logger will capture BAM-1020 data within the correct hour, the BAM-1020 MUST be configured in the 'Early' cycle mode. To configure the BAM-1020 to "EARLY' cycle mode:

1) Press the "**SETUP**" soft key.

2) Use the arrow keys to move the cursor to the word 'INTERFACE' and press the "**SELECT**" soft key.

3) The word 'EARLY' should be displayed to the immediate right 'Cycle Mode:'.

4) If the word 'STANDARD" is displayed, press the up arrow key once. The word 'EARLY' should appear.

5) Change 'STANDARD' to 'CYCLE' by pressing the down arrow key once.

6) Press the "**SAVE**" soft key.

7) Press the "**EXIT**" soft key.

8) Confirm 'EARLY' cycle mode configuration by performing steps 1 through 3.

BAM-1020 'offset' voltage output configuration: All ARB BAM-1020 monitors are initially configured with a negative offset of -0.005 VDC. This offset works in combination with the ESC data logger configurations listed in section 3.2 and only affects the voltage output to the ESC data logger. With this negative offset, the data logger has the capacity of calculate and store negative values. The ability for the ESC data logger to collect negative values have proved essential when trying to determine if a BAM-1020 monitor is working correctly.

To configure the BAM-1020 monitor with the correct offset:

1) Press the "**SETUP**" soft key.

2) Use the arrow keys to move the cursor over to the word 'sample' and press the key under the word "**SELECT**".

3) Using the side arrow keys, move the cursor down to the bottom right (offset). With the up and down arrow keys, change the offset value to -0.005.

4) Press the "**SAVE**" soft key.

5) Press the “**EXIT**” soft key.

6) Confirm offset configuration by performing steps 1 through 3.

Differences in ESC and BAM-1020 data logger values should consistently read no more than 1.0 ug/m3 from each other. After collecting several hourly data points, adjust Either the ESC or BAM-1020 offset voltage output so that the ESC data is always equal to or 1.0 ug/m3 less than the BAM-1020 data set. Currently, the BAM-1020 data set expresses the hourly average of the ending time. For example, the averages logged by the BAM-1020 at 9:00 am were actually collected during the 8:00 hour. Data collected during the 8:00 am hour will be logged by the ESC data logger as 8:00 am data. The relationship between ESC and BAM-1020 data should be checked during each monthly data set review.

Volumetric flow mode configuration: Depending on the firmware version, there are two or three different configurations for flow; 1) ‘METERED’ and ‘VOLUMETRIC’ and 2) 'METERED', 'STD' and 'ACTUAL' (the calibration process is different for each mode). For Federal Reference Method (FRM) PM2.5 filter comparability, all ARB deployed BAM-1020 monitors are configured for 'VOLUMETRIC’ or 'ACTUAL' flow control. To check the BAM-1020 for correct ‘VOLUMETRIC’ or 'ACTUAL' flow control configuration:

1) Press the “**SETUP**” soft key.

2) Use the arrow keys to move the cursor over to the word ‘Calibrate’ and press the “**SELECT**”.

3) The word ‘VOLUMETRIC’ or 'ACTUAL' should be displayed to the immediate right of ‘FLOW TYPE’. If not, use the arrow keys to set correct flow type.

4) Press the “**SAVE**” soft key.

5) Press the “**EXIT**” soft key.

6) Confirm ‘VOLUMETRIC’ or 'ACTUAL' flow control configuration by performing steps 1 through 3.

3.2 Configure ESC data logger:

ESC **8800** data logger configuration: Configuring the ESC 8800 to the BAM-1020 will require initializing two channels (channel 06 for data acquisition and channel 32 for contact closure function).

ESC **8800** data channel (06) configuration: Channel 06 will be configured for BAM-1020 data acquisition for all ARB sites with Met One BAM Monitors. The configuration used will be a one-hour tape sample mode that collects only the last minute of data for each hour, using that minute of data to represent the hourly average for the same hour. The ESC 8800 program configuration is as follows:

LIST 00
CHANNEL NUMBER: 06
CHANNEL NAME: BAM
CHANNEL TYPE: D
STORE HOURLY AVERAGES: Y
    HOURLY SIGMAS: N
    HOURLY % VALID: N
    HOURLY RANGE: N
STORE AUX AVERAGES: N
CHANNEL UNITS: UG/M3
VOLTS FULL SCALE: 1.000
SLOPE: 1000.
INTERCEPT: -5.000
DECIMAL POSITIONER: 0
MAX READING: 9999.
MIN READING: -999.0
MAX RATE OF CHANGE: 5000.
ALARM INTERVAL [N,M,A,H]: N
BAD STATUS= XXXXXXXX XXXXXXXX
CALIBRATION TYPE: N
10-STEP CALIBRATION: N
ON-LINE: Y

ESC **8800** Contact closure configuration: Channel 32 has been selected on the ESC 8800 as the TRIGR channel. The TRIGR channel configuration is as follows:

LIST 32
CHANNEL NUMBER: 32
CHANNEL NAME: TRIGR
CHANNEL TYPE: 9
STORE HOURLY AVERAGES: N
STORE AUX AVERAGES: N
CHANNEL UNITS:
VOLTS FULL SCALE: 10.00
SLOPE: .0000
INTERCEPT: .0000
DECIMAL POSITIONER: 0
MAX READING: 9999.
MIN READING: -999.0
MAX RATE OF CHANGE: 5000.
ALARM INTERVAL [N,M,A,H]: N
BAD STATUS= XXXXXXXX XXXXXXXX
CALIBRATION TYPE: A
WEEKLY ALT CAL: N
AUTO-CAL START TIME: 00:55
ZERO LINES: 06,00,00 * (this set point designates digital output channel 06)
ZERO DURATION TIME: 01
ZERO RESPONSE TIME: 01
SPAN1 LINES: 00,00,00
SPAN1 DURATION TIME: 00
SPAN1 RESPONSE TIME: 00
SPAN2 LINES: 00,00,00
SPAN2 DURATION TIME: 00
SPAN2 RESPONSE TIME: 00
RECOVERY TIME: 00
CAL SEQUENCE: Z12
EXPECTED SPAN1, SPAN2: .0000, .0000
10-STEP CALIBRATION: N
ON-LINE: Y

ESC **8816** data logger configuration: Configuring the ESC 8816 to the BAM monitor requires initializing two data channels and one digital out configuration. Channel 32 will be initialized as the input data cannel or BAM_RAW channel, channel 06 will be initialized as the Average Math Channel or BAM25 Channel.

During normal operation, Channel 32 will continuously minute average data from the BAM-1020. This minute average data will not be stored anywhere. Channel 06 will continuously look at Channel 32 minute averages and calculate ug/m3 values, but Channel 06 will only store the last minute of each hour that is generated by Channel 32. Therefore, the last minute average of each hour generated by Channel 32 is calculated and stored on Channel 06 and reported as the hourly average.

System configuration:

ESC 8816 v5.34 ID:01 System Configuration Screen 11/15/00 13:55:43

Logger Date	:	11/15/00
Logger Time	:	13:55:40
Time Zone	:	PST
Logger ID Code	:	01
Station ID Code	:	
Logger Description	:	ESC 8816
Baud Rate - Ext. Modem	:	9600
Baud Rate - Port 1	:	9600
Baud Rate - Port 2	:	N/A
Baud Rate - Port 3	:	N/A
Parallel Port Timeout	:	5s
Automatic Logout Time	:	1h
% For Valid Base Avg	:	100
% For Valid Ext. Avg	:	75
Debounce Digital Inputs ?	:	N
Default Dig. Inputs to OR ?	:	N
Math Update Rate	:	2
Alarm Deadband (% of limit)	:	0.0
Allow Auto Corr if Config'd?	:	Y

Standard Cannel Configuration:

ESC 8816 v5.34 ID:01 Standard Channel Config. 11/15/00 13:45:10

Instrument Name	:	BAM_RAW
Analog Input Number	:	32
Report Channel Number	:	32
Volts Full Scale	:	1
High Input	:	1 V
Low Input	:	0 V
High Output (E.U.s)	:	995
Low Output (E.U.s)	:	-5
Units	:	UG/M3
Base Avg. Interval, Storage	:	1m , 1d 55m
Average #1 Interval, Storage	:	15m , 0s
Average #2 Interval, Storage	:	1h , 0s
Use 40CFR75 Validation (Y/N)	:	N
FINISHED (Configure Now)	:	11/15/00 11:14:18

Average Validation Configuration:

To configure the following 'Average Validation Configuration' parameters, move the cursor in the above menu to the 'Base Avg. Interval, Storage : 1m , 1d 55m' line and press 'CTRL' 'V' (the 'CTRL' function requires pressing both blue and orange keys simultaneously).

ESC 8816 v5.34 ID:01 Average Validation Config. 11/15/00 13:43:19

High-High Alarm Limit (H)	:	E+10
High Alarm Limit (h)	:	1E+10
Low Alarm Limit (l)	:	-1E+10
Low-Low Alarm Limit (L)	:	-1E+10
High ROC Alarm Limit (J)	:	1E+10
Low ROC Alarm Limit (j)	:	1E+10
Floor Limit (f)	:	-1E+10
Floor Value	:	0
Ceiling Limit (c)	:	1E+10
Ceiling Value	:	0
Percent for valid average	:	Default (100)
Average to Math Constant	:	K1

Configure Channel Options:

ESC 8816 v5.34 ID:01 Config. Channel Options 11/15/00 13:44:45

Name (not editable)	:	BAM_RAW
Chl Number (not editable)	:	32
Decimal Positioner	:	00
Span for Cal Err	:	(not set)
Round Precision	:	(none)

Average Math Channel Configuration:

ESC 8816 v5.34 ID:01 Average Math Channel Config. 11/15/00 13:47:43

Instrument Name	:	BAM25
Report Channel Number	:	06
Equation	:	K1=
Units	:	UG/M3
Base Avg. Interval, Storage	:	1m , 0s
Average #1 Interval, Storage	:	15m , 0s
Average #2 Interval, Storage	:	1h , 14d 9h
Round Constituents: (Y/N)	:	N
Use 40CFR75 OOC (Y/N)	:	N
FINISHED (Configure Now)	:	11/15/00 10:38:54

Instrument Validation Configuration:

ESC 8816 v5.34 ID:01 Inst. Validation Config. 11/15/00 13:48:54

Bad Status Lines (B)	:	(none)
Maintenance Status Lines (M)	:	(none)
Boiler Offline Status (F)	:	(none)
Maximum Reading Limit (+)	:	1E+10
Minimum Reading Limit (-)	:	-1E+10
Rate of Change Limit (R)	:	1E+10
Digital Info Status #1 (V)	:	(none)
Digital Info Status #2 (W)	:	(none)
Digital Info Status #3 (X)	:	(none)
Digital Info Status #4 (Y)	:	(none)
Digital Info Status #5 (Z)	:	(none)

Digital Event Program Configuration:

ESC 8816 v5.34 ID:01 Config. Dig. Event Program 11/15/00 13:51:26

Dig. Event Program Name	:	BAM
Starting Time	:	11/15/00 13:55:00
Repeat Interval	:	1h
Output Line(s)	:	6, *(designates ch, digital out)
Output Duration	:	5s
Disable During Cal(s)	:	(none)

4.0 SELF TEST

Performing the BAM-1020 'SELF TEST' checks both the current operational status and resets any error codes that may exist. The BAM-1020 can generate an error code whenever an expected set point can not be maintained, as when a low flow condition occurs or when the filter tape runs out. **It is highly recommended to perform a 'SELF TEST' following the BAM-1020 installation, after the routine filter tape change, when troubleshooting and after correcting any problem**.

The BAM-1020 self test is performed by the following steps:

1. In the BAM-1020 main menu, press the "**TAPE**" soft key.

2. Next, press the "**SELF TEST**" soft key.

3. If all BAM-1020 checks pass, the display will read 'Status: SELF TEST PASSED'. If the display reads 'FAILED', remedy the problem and rerun 'SELF TEST'. Most likely, the condition that caused the 'SELF TEST' failure will be indicated on the display.

4. At the completion of the BAM-1020 'SELF TEST', press the "**EXIT**" soft key to return to the main menu.

5.0 CALIBRATION INFORMATION

5.1 Calibration Introduction: The purpose of this section is to outline the Met One Beta Attenuation Mass Monitor, model 1020 (BAM-1020) verification and calibration procedures used by the AIR Quality Surveillance Branch of the California Air Resources Board (ARB). The Met One Instrument's BAM-1020 Operation Manual is an important resource of information for BAM-1020 calibrations, and therefore ARB highly recommends a thorough review of the BAM-1020 Operation Manual.

5.2 Calibration Overview: The BAM-1020 requires the calibration of the outside temperature sensor (OT), the internal pressure sensor and the volumetric flow controller. Depending on the firmware version of the BAM-1020, there are either two or three different flow configurations. Older firmware designate "METERED' or 'VOLUMETRIC' flow. Current firmware versions designate 'METERED', 'STD' or 'ACTUAL' flow. The 'METERED' configuration controls flow at standard conditions and calculates the hourly average mass value in terms of standard flow conditions, flow is not controlled using local temperature and pressure information. The 'STD' configuration controls flow using actual conditions (applying local temperature and pressure conditions) but will calculate the hourly averaged mass value at standard temperature and pressure conditions. 'VOLUMETRIC' and 'ACTUAL' flow will control and calculate flow using actual (local temperature and pressure) conditions. All BAM-1020 monitors purchased by ARB will be configured in the 'VOLUMETRIC' or 'ACTUAL' flow mode (thus requiring the installation of an OT sensor). When configuring or calibrating the BAM-1020, a password is required. The default password is F1 F2 F3 F4.

Met One BAM-1020 is calibrated using the following steps:

1. Leak Check
2. BAM-1020 flow control check
3. Outside temperature (OT) calibration/verification.
4. Internal pressure calibration/verification.
5. Volumetric flow calibration/verification.

Record all calibration information and data.

It is important to exit back to the main menu between each complete calibration parameter. As with most software driven monitoring equipment, returning to the main menu between calibrations can be imperative when adjustments are made to specific components that ultimately impact the calibration and/or operation of the instrument's other components. Exiting out of the calibration screen and returning to the main menu between calibrating each component allows the BAM-1020 to completely update any configurations or changes made. Temperature and pressure changes are especially critical with respect to the BAM-1020's volumetric flow control.

Checking the BAM-1020 flow controller will help determine proper operation and aid as a troubleshooting technique. By changing the BAM-1020 16.7 volumetric liter per minute (VLPM) flow set point to a lower and a higher value, the operator can determine if the BAM-1020 flow controller is capable of re-adjusting and holding at the new flow value and therefore operating properly. Checking the BAM-1020 flow controller can be accomplished by accessing the "SETUP" menu and selecting the 'sample' screen. Change the 16.7 VLPM set point to a lower flow rate (maybe around 13 VLPM) and select save. Exit and turn on the BAM-1020 flow by going through the "TEST" menu, selecting 'FLOW' and turning on the pump. The 'BAM' flow should adjust to the new set point and hold steady. Go back and change the BAM-1020 flow set point higher than 16.7 VLPM (somewhere around 18 VLPM) and check. If the BAM-1020 adjusts and holds at both flow set points, then the BAM-1020 flow controller is most likely operating properly. If the BAM-1020 flow does not adjust to one or both flow set points, then a problem is present and requires immediate correction. If the BAM-1020 can adjust and hold at a flow lower than 16.7 VLPM but not at a flow higher 16.7 VLPM, then a leak between the pump and flow meter or a tired pump could be the cause. If the BAM-1020 'BAM' flow does not adjust downward to a set point lower than 16.7 VLPM, then a bad flow controller is most likely the culprit.

5.3 Apparatus for BAM-1020 Calibration

1. NIST-traceable mass flow transfer standard*
2. NIST-traceable temperature meter
3. NIST-traceable pressure meter
4. Tubing
5. Calibration forms or laptop computer

*__Note__: Other flow measuring devices may be substituted, such as the R&P FTS Streamline Calibration Kit or BGI Delta/Tri Cal.

6.0 CALIBRATION PROCEDURE

6.1 Calibration Transfer Standards and Equipment: All calibration transfer standard equipment must possess up-to-date certification. Certified temperature and pressure sensors are required for both BAM-1020 outside temperature and pressure calibrations. A certified mass flow meter or certified fixed orifice device (such as the FTS Streamline) will be required for flow calibrations.

Allow all AC powered equipment to equilibrate to ambient conditions for a minimum of one (1) hour.

6.2 Temperature Sensor Calibration (OT): The BAM-1020 external OT sensor is calibrated by initiating the BAM-1020 temperature calibration sequence and entering a single ambient temperature value. Perform the following steps to calibrate the BAM-1020 OT sensor:

1. In the BAM-1020 main menu, press the "**TEST**" soft key.

2. Using the right arrow key, move the cursor over to the word 'FLOW' and press the "**SELECT**" soft key.

3. With the arrow keys, enter the corrected ambient temperature (in ^{0}C from the certified temperature standard), on the row to the right of 'AMBIENT TEMPERATURE', under the column labeled 'REFERENCE'.

4. Press the "**ADJUST/SAVE**" soft key.

5. Press the "**EXIT**" soft key.

6. Confirm OT calibration by performing steps 1 through 3.

6.3 Barometric Pressure Sensor Calibration:

The BAM-1020 internal barometric pressure sensor is calibrated by initiating the BAM-1020 barometric sensor calibration sequence and entering a single ambient pressure value. Perform the following steps to calibrate the BAM-1020 barometric pressure sensor:

1) Press the "**TEST**" soft key from the main menu.

2) Using the right arrow key, move the cursor over to the word 'FLOW' and press the "**SELECT**" soft key.

3) Press the "**NEXT**" soft key.

4) With the arrow keys, enter the corrected ambient pressure (in mmHg) on the row to the right of 'BAROMETRIC PRESSURE', under the column labeled 'REFERENCE'.

5) Press the "**ADJUST/SAVE**" soft key.

6) Press the "**EXIT**" soft key.

7) Confirm the internal pressure calibration by performing steps 1 through 3.

6.4 Volumetric Flow Rate Calibration

The BAM-1020 volumetric flow controller is calibrated by initiating the BAM-1020 volumetric flow calibration sequence and entering a single through-the-inlet volumetric flow value. To acquire the correct volumetric flow value, remove the PM10 inlet and measure the standard mass flow of the BAM-1020 (leave the PM2.5 SCC inlet attached to the inlet tube if sampling PM2.5). Convert the measured standard flow to volumetric flow using a certified transfer standard ambient temperature and pressure values. Enter the calculated volumetric flow into the BAM-1020 by:

1) Press the "**TEST**" soft key.

2) Using the right arrow key, move the cursor over to the word 'FLOW' and press the "**SELECT**" soft key.

3) Press the "**PUMP ON**" soft key and allow pump to run for several minutes (the cursor will automatically move to the 'VOLUMETRIC FLOWRATE' row under the column labeled 'REFERENCE'. **The value in the** 'VOLUMETRIC FLOWRATE' **row under the** 'BAM' **column must read 16.7**.

4) At the inlet on the rooftop, remove the PM10 inlet and measure the standard flow rate through the inlet tube (leave the PM2.5 inlet on if present).

5) Calculate the volumetric flow rate. The equation to convert standard flow rate to volumetric flow is:

$$\text{Volumetric flow} = \frac{(\text{std. flow}^*)(760\text{ mm Hg})(\text{ambient temp in K})}{(\text{ambient pressure in mm Hg})(298\text{ K})}$$

*Note: std. mass flow meter values are calculated by:

std. flow = [(MFM disp)(MFM cert. slope)] + (MFM cert. intercept)

6) With the arrow keys, enter in the calculated volumetric flow rate.

7) Press the "**ADJUST/SAVE**" soft key.

8) Press the "**EXIT**" soft key (pressing the "**EXIT**" soft key will automatically turn off the pump).

9) Verify the correct flow rate by repeating steps 1 through 3. The calculated volumetric flow must be within +/- 2% of 16.67 L/min (16.34 to 17.00 LPM). The equation for calculating the percent difference is:

$$\% \text{ diff.} = \frac{(\text{Volumetric flow} - 16.67)}{16.67} \times 100\%$$

7.0 BAM-1020 VERIFICATION PROCEDURES

7.1 Flow Rate Verification: The flow rate can be verified using one of two procedures. One flow verification procedure can be performed while the BAM-1020 is in 'normal' operating mode. The other flow verification procedure can be performed by keying into the BAM-1020 flow calibration screen and turning on the pump. The preferred method for biweekly flow checks or biannual calibration is while the BAM-1020 is running in the 'normal' operating mode. When verifying flow after a BAM-1020 flow calibration, it will be more efficient to verify flow using the calibration mode procedure (this is because it may take up to two (2) hours for the BAM-1020 to start operating after it is placed in 'normal' operating mode). Perform either flow rate verification procedure by removing only the FRM PM10 impactor and measuring the flow through the inlet tube (leave on the PM2.5 sharp cut cyclone if configured). To meet flow verification criteria, the calculated volumetric flow must be within 4% of 16.67 VLPM (16.00 to 17.34 VLPM).

Verifying flow in 'normal' operating mode: To verify the flow in 'normal' operating mode, simply remove the FRM PM10 impactor and measure the flow. The BAM-1020 pump only operates for fifty (50) minutes of each hour. Verify that the pump is running when the checking flow in the 'normal' operating mode.

Verifying flow in flow calibration mode: Verify BAM-1020 flow rate only through the "**TEST**" screen. Be sure NOT to press the "ADJUST/SAVE" soft key during this procedure. To verify the BAM-1020 the flow calibration:

1) Press the "**TEST**" soft key.

2) Using the right arrow key, move the cursor over to the word 'FLOW' and press the "**SELECT**" soft key.

3) Press the "**PUMP ON**" soft key and allow pump to run for several minutes (the cursor will automatically move to the 'VOLUMETRIC FLOWRATE' row under the column labeled 'REFERENCE'. **The value in the** 'VOLUMETRIC FLOWRATE' **row under the** 'BAM' **column must read 16.7**.

4) At the inlet on the rooftop, remove the PM10 inlet and measure the standard flow rate through the inlet tube (leave the PM2.5 inlet on if present).

5) Calculate the volumetric flow rate. The equation to convert standard flow rate to volumetric flow is:

$$\text{Volumetric flow} = \frac{(\text{std. flow})(760 \text{ mm Hg})(\text{ ambient temp in K})}{(\text{ambient pressure in mm Hg})(298 \text{ K})}$$

6) Verify the correct flow rate by repeating steps 1 through 3. The calculated volumetric flow must be within +/- 2% of 16.7 L/min. The equation for calculating the percent difference is:

$$\%\text{ diff.} = \frac{(\text{Volumetric flow} - 16.7)}{16.7} \times 100\%$$

7) Press the "**EXIT**" soft key (pressing the "**EXIT**" soft key will automatically turn off the pump).

7.2 Temperature Sensor Verification: To verify the BAM-1020 external OT sensor:

1) Press the "**TEST**" soft key.

2) Using the right arrow key, move the cursor over to the word 'FLOW' and press the "**SELECT**" soft key.

3) Compare the BAM-1020 temperature value listed on the row to the right of 'AMBIENT TEMPERATURE', under the column labeled 'BAM' to the corrected ambient temperature standard value.

4) Record and calculate the percent difference from the corrected ambient certified temperature transfer standard value.

5) Remain in this screen for ambient pressure verification or press the "**EXIT**" soft key.

7.3 Barometric Pressure Verification: To verify the BAM-1020 external OT sensor:

1) Press the "**TEST**" soft key.

2) Using the right arrow key, move the cursor over to the word 'FLOW' and press the "**SELECT**" soft key.

3) Compare the BAM-1020 internal barometric pressure value listed on the row to the right of 'BAROMETRIC PRESSURE', under the column labeled 'BAM' to the corrected ambient pressure standard value.

4) Record and calculate the percent difference from the corrected ambient certified pressure transfer standard value.

5) Press the "**EXIT**" soft key.

7.4 Clock/Timer Verification: Compare the date and time of the BAM-1020 clock display to the ESC data logger date and time display. If either the date or time of the BAM-1020 does not agree with the ESC data logger, correct the BAM-1020 to match the ESC data logger. The BAM-1020 clock should be set to as close to the ESC data logger as possible (within thirty (30) seconds). If the BAM-1020 clock drifts significantly from the ESC data logger, then the data will become flagged. Clock drift indicates that a problem may exist with the contact closure relay configuration. Diagnose and correct.

All clocks are set to Pacific Standard Time (PST).

8.0 START SAMPLING

To start sampling:

From the main menu, press the "**OPERATE**" soft key.

Press the "**NORMAL**" soft key. In most cases, the BAM-1020 will typically start sampling at the beginning of the next hour if the BAM-1020 is configured to start no later than six (6) to ten (10) minutes before the beginning of the next hour. Tape movement will occur approximately five (5) minutes before the beginning of the next collection cycle (for tape zero reading). The BAM-1020 pump will turn on at the beginning of the hour and run for fifty (50) minutes.

9.0 LEAK CHECK

The BAM-1020 requires a leak check after installation and on a bi-weekly basis to ensure proper operation and data quality. The installation leak check should be performed prior to temperature, pressure and flow calibration. The biweekly leak check should be performed after the biweekly flow check. Leak check information should be recorded on the BAM-1020 monthly quality control maintenance check sheet (Appendix A).

To perform a leak check, remove the FRM PM10 inlet from the BAM-1020 inlet system. Cap off the flow at the inlet of the PM2.5 SCC. Capping off the inlet flow can be achieved by using a PM2.5 FRM adaptor with stopcock or a rubber stopper. The flow display on the BAM-1020 must read less than **1.0** LPM with the inlet capped off to pass the manufacturers recommended leak check specifications. The leak check flow value on the display screen of the BAM-1020 should stabilize in less than 20 seconds to within two to three tenths of a liter per minute (0.2 – 0.3 lpm). Ensure that the leak check flow value remains stable for a minimum of fifteen (15) to twenty (20) seconds. It is recommended NOT to leave the BAM-1020 capped off in the leak check mode for any period of time longer than necessary.

A leak check value between 0.7 and 1.0 LPM still passes but indicates the potential of a leak check failure in the near future.

Note: Perform the BAM-1020 “SELF TEST’ before returning to normal sampling operation. Performing a leak check will generate an error code in the BAM-1020 due to the insufficient flow through the inlet. Performing a ‘SELF TEST’ will reset the BAM-1020. The ‘SELF TEST’ procedure is described above in section **4.0** of this document.

10.0 ROUTINE SERVICE CHECKS

10.1 General Information: Perform the following checks on the BAM-1020 at the intervals specified in the service schedule. The checks may be performed more frequently but should be performed at least within the prescribed intervals. Document all check information and maintenance on the Monthly Quality Control Maintenance Check Sheet (Appendix A).

10.2 Daily Check: Review station datalogger values for correct operation of the BAM-1020.

10.3 Weekly Checks: Check the BAM-1020 filter tape and replace when necessary. One roll of filter tape is 22 meters long and will last for a minimum of 60 days.

10.4 Bi-weekly Checks:

1) Flow check: Perform an inlet flow verification to ensure a flow rate of 16.67 VLPM (+/- 4 percent). Remove only the PM10 inlet when measuring flow.

2) Leak check: Perform a Leak check. A BAM-1020 display of less than 1.0 LPM passes the manufacturers leak check specifications.

The bi-weekly flow check can be performed while the BAM-1020 is in normal operating mode. Remove only the FRM PM10 inlet from the BAM-1020 inlet system. Affix either a mass flow measuring or volumetric flow measuring device onto the PM2.5 SCC inlet and record the volumetric flow on the monthly quality control maintenance check sheet.

10.5 Monthly Checks:

1) Complete and submit the BAM-1020 Monthly Quality Control Maintenance Check Sheet (Appendix A).

2) Thoroughly clean both the PM2.5 Sharp Cut Cyclone (SCC) and the PM10 FRM inlets.

3) Download and submit BAM-1020 data logger data with charts and maintenance sheets.

10.6 Semi-Annual Checks: Perform semi-annual BAM-1020 verification/calibration of the external ambient temperature, internal pressure, leak check and volumetric flow.

11.0 MAINTENANCE PROCEDURES

11.0 General Information: Normal BAM-1020 maintenance requires keeping the BAM-1020 central unit dust free and inlet cleaning.

11.1 Sampler Maintenance: As with all monitoring equipment, the BAM-1020 should be kept clean and dust free.

11.2 PM2.5 Sharp Cut Cyclone (SCC) Maintenance: The PM2.5 SCC inlet requires removal from the inlet tube, disassembly and cleaning. The inlet should be thoroughly cleaned every month. Disassemble the SCC and wipe clean with lint free cloth. Ensure that all ‘O’ ring surfaces are in excellent shape and are re-installed correctly. Replace 'O' rings when needed.

11.3 PM10 Inlet Maintenance: The PM10 inlet requires removal from the inlet tube, disassembly and cleaning. The inlet should be thoroughly cleaned every month. Disassemble the PM10 inlet and wipe clean with lint free cloth. Ensure that all ‘O’ ring surfaces are in excellent shape and are re-installed correctly. Replace 'O' rings when needed.

12.0 TROUBLESHOOTING and RETRIEVING BAM-1020 INTERNAL DATA

A desktop or laptop computer is an important tool when verifying proper data logger acquisition and troubleshooting. Error codes, current BAM-1020 configurations and BAM-1020 data can be observed and downloaded using the Microsoft Windows HyperTerminal software program. The HyperTerminal Properties and Advanced Port Settings are:

1. Properties Screen:

   Bits per second: 9600
   Data bits: 8
   Parity: None
   Stop bits: 1
   Flow control: None

2. Advanced Port Settings Screen: Remove check from “Use FIFO buffers”.

Connect the computer port cable to the upper RS232 connector located at the rear of the BAM-1020. Activate the HyperTerminal program and press the computer’s return button a couple times. An asterisk (*) should appear. If not, depress the small white and red polarity toggle switch located next to the RS232 connector on the back of the BAM-1020. Type the letter H and a menu will appear. To download BAM-1020 data to a laptop or desk computer, the ‘Capture Text’ function of HyperTerminal can be used.

Should the BAM-1020 fail to operate, refer to section 10.3 of the BAM-1020 operating manual. This section contains a troubleshooting guide that outlines symptoms, checkpoints, probable cause and remedies for general problems.

BAM-1020 download data: BAM-1020 data shall be downloaded from the monitor and compared to ARB's AQDAS EMC data (remembering that the BAM-1020 data will stagger the EMC data by one hour).

Negative data: All valid BAM-1020 EMC negative hourly values shall be corrected to zero (as with all of ARB's continuous monitoring programs). Repeating values or an abundance of -5 ug/m3 values should be suspect to monitor malfunction. If these either case appears, check for proper operation of monitor or for background drift using an appropriate zero air filter.

Daily Data Patterns: BAM-1020 data should express somewhat routine characteristics for each specific site. 'Flat' or erratic hour to hour mass values may be the result of an operational malfunction. Changes in weather such as rain or seasons should influence 'normal' daily values.

Qtot Validation Criteria: The 'Qtot' value recorded in the BAM-1020 data logger is the average hourly volume measured during each sample. Fifty (50) minutes of a 16.67 LPM flow equals 0.8335 m^3:

$$\frac{(50 \text{ minutes})(16.67 \text{ liters})(1 \text{ m3})}{(1 \text{ Minute})(1000 \text{ liters})} = 0.8335 \text{ m}^3$$

Therefore, the ideal hourly 'Qtot' value will be rounded and recorded as 0.834 m^3. This Qtot is an indication that the BAM-1020 flow was operating at the 16.7 LPM set point and stable throughout the sampling period. **The 'Qtot' value is an important validation criteria data point for each hourly average mass value. The 'Qtot' validation criterion is 0.830 - 0.837 m^3.**

CARB MONTHLY QUALITY CONTROL MAINTENANCE CHECK SHEET
BAM-1020 SAMPLER

Site Name: _____ Month/Year: _____
Site Number: _____ Sampler Make & Model: _____
Operator/Agency: _____ Sampler ID Number: _____
Date of Last Calibration: _____

Instrument Checks:

1) Daily checks: Review station data logger values for correct operation of BAM-1020.
2) Weekly checks: Check filter tape & replace when necessary (approx. 2 months per roll).
3) Bi-Weekly checks: Perform BAM-1020 flow and leak.
4) Monthly checks: Complete and submit this Monthly Quality Control Check Sheet.
   Thoroughly clean both PM2.5 SCC and PM10 FRM inlets.
   Check pump muffler and replace when needed.
   Download and submit data from BAM-1020 data logger.

Sampler Flow Rate, Ambient Temp and Pressure Check Results:

	Flow Rate Standard			Temperature Standard			Pressure Standard		
Standard Make/Model:									
Std. ARB ID Number:									
Std. Certification Date:									
Standard Slope:									
Standard Intercept:									
Date Checked:									
Std. Display Reading:									
Std. 'Actual' Reading:									
BAM-1020 Display:									
Design Flow % Diff.:									
Leak Check Value:									

Volumetric Flow Acceptance Criteria: <+/-4% of 16.67 LPM (16.00 to 17.34 VLPM)

Operator Comments:

_____
_____
_____

Reviewed by_____

Appendix A

AQSB QC Form 400 (BAM)

ARB Calibration Report - BAM-1020

Met One Beta Attenuation Mass Monitor

Includes Mass Flow Meter (MFM), FTS Streamline and BGI Delta/Tri Calibration

ID Information:

Station Name:	Station		As Is:	X
Site #:	00-000		Final:	
Property #:	20000000		Calib. Date:	02/17/03
Agency:	ARB		Last Cal:	08/08/01

Pressure & Temperature Transfer Standard:

	slope (m) :		Intercept (b):		
True Press. =	0.9999	* Display +	1.059	Flow Std. ID#:	20000001
True Temp. =	1.0004	* Display +	-0.1045	Flow Cert.Date:	01/02/03
MFM 30 L =	0.9957	* Display +	0.0156	P/T Std.ID#:	20000002
FTS Streamline =	0.4050	* Display +	-0.5673	P/T Cert. Date:	01/02/03

Flow Controller Check	Pass/Fail
13.0 LPM:	
18.0 LPM:	

Flow Device Used:	
MFM	
FTS	
BGI	X

Temperature Sensor Calibration:

BAM Temp. Display:	Std. Temp. Display:		MFM Temp:	FTS Temp K:	BGI Temp:
		Corrected Temp:	12.38	285.53	12.48
12.50	12.48	Diff. In degrees:	0.12	0.12	0.02

Temperature = +/- 2.0 Celsius

Pressure Sensor Calibration:

BAM Press.Display:	Std. Press. Display:		MFM Press.:	FTS (Atm):	BGI Pressure:
		Corrected Press.:	764.0	1.01	763
759	763	Diff. In Pressure:	-5.0	-5.0	-4.0

Pressure = +/- 10 mm Hg

Flow Calibration:

BAM Flow Display:	Std. Display:		MFM Flow:	FTS Flow:	BGI Flow:
		Corrected Flow:	16.72	27.39	16.78
16.71	16.78	% Diff.:	0.32%	64.33%	0.66%

Flow = +/- 2.0%

Flow Verification:

BAM display:	Std. Display:		MFM Ver.:	FTS Ver.:	BGI Ver.:
		Corrected Flow:	16.66	27.34	16.72
16.71	16.72	% Diff.:	-0.04%	64.03%	0.30%

Flow = +/- 2.0%

Comments:		
Calibrated by:		Checked by:

Appendix B

AQSB Calibration Form 400 (BAM)

BAM-1020 Instrument Data (Example)

```
* 2
  Report for 12/10/2002 - Day 344    > BAM 1020 <    Station ID:  1

Channel                            01     02     03     04     05     06 Sensor
          Conc   Qtot   WS     WD     ROOM   RH     BP     AT
Units                mg     m3     Kts    Deg    C      %      "Hg    C
=============================================================================
00:00 ------------ -0.002  0.834  000.4  360.0  170.0  099.7  26.00  001.1
01:00 ------------ -0.003  0.834  000.4  360.0  170.0  099.7  26.00  001.2
02:00 ------------ -0.001  0.834  000.4  360.0  170.0  099.7  26.00  001.5
03:00 ------------ -0.001  0.834  000.4  360.0  170.0  099.7  26.00  001.3
04:00 ------------  0.000  0.834  000.4  360.0  170.0  099.7  26.00  001.5
05:00 ------------  0.001  0.834  000.4  360.0  170.0  099.7  26.00  001.5
06:00 ------------ -0.004  0.835  000.4  360.0  170.0  099.7  26.00  000.5
07:00 ------------ -0.005  0.834  000.4  360.0  170.0  099.7  26.00  000.6
08:00 ------------ -0.004  0.834  000.4  360.0  170.0  099.7  26.00  000.5
09:00 ------------ -0.005  0.834  000.4  360.0  170.0  099.7  26.00  001.1
10:00 ------------ -0.005  0.834  000.4  360.0  170.0  099.7  26.00  001.6
11:00 ------------ -0.004  0.834  000.4  360.0  170.0  099.7  26.00  002.4
12:00 ------------ -0.005  0.834  000.4  360.0  170.0  099.7  26.00  003.4
13:00 ------------ -0.005  0.834  000.4  360.0  170.0  099.7  26.00  004.2
14:00 ------------ -0.005  0.834  000.4  360.0  170.0  099.7  26.00  004.3
15:00 ------------ -0.005  0.835  000.4  360.0  170.0  099.7  26.00  003.5
16:00 ------------ -0.005  0.834  000.4  360.0  170.0  099.7  26.00  003.3
17:00 ------------ -0.003  0.834  000.4  360.0  170.0  099.7  26.00  001.7
18:00 ------------ -0.001  0.835  000.4  360.0  170.0  099.7  26.00  000.2
19:00 ------------  0.003  0.834  000.4  360.0  170.0  099.7  26.00 -002.0
20:00 ------------ -0.000  0.834  000.4  360.0  170.0  099.7  26.00 -002.6
21:00 ------------ -0.003  0.834  000.4  360.0  170.0  099.7  26.00 -003.1
22:00 ------------ -0.005  0.834  000.4  360.0  170.0  099.7  26.00 -003.5
23:00 ------------ -0.005  0.834  000.4  360.0  170.0  099.7  26.00 -004.0

Savg               -0.003  0.834  000.4  360.0  170.0  099.7  26.00  000.8
Vavg                0.000  0.000  000.0  000.0  000.0  000.0  00.00  000.0

Data Recovery 100.0 %
```

BAM-1020 Error Log (Example)

```
* 7
09/04/02 07:52, Power Fail
09/04/02 08:17, Power Fail
09/10/02 07:34, Power Fail
09/19/02 12:49, Power Fail
09/26/02 09:35, Pressure
12/11/02 10:46, Power Fail
12/11/02 16:08, Power Fail
12/12/02 09:41, Power Fail
12/12/02 09:55, Tape
12/16/02 15:41, Power Fail
12/16/02 15:41, Tape
12/16/02 15:41, Power Fail
```

Appendix C

BAM-1020 Configuration (Example)

```
* 4
------------------------------------------------------------
|      > BAM 1020 <  SETUPS   12/17/2002    10:19:12       |
------------------------------------------------------------

BAM Sample Time: 050 Minute(s)

MET Sample Time: 60  Minute(s)

ABS: 0.825

mu: 0.285

K: 0.969

BKGD: -0.010

Cv Qo: 0.984 0.000

E1 E2 E3 E4: -0.005 0.500 0.000 15.000

DAC Mask: = 0x0fff

Ap FRl FRh: = 150.000 10 20

Cp Cm I% F%: = 50.000 -20.000 99 99

RS232: 9600 N 8 1

Firmware Ver: 2.21.01

Station ID: 01

Channel Identification:

Channel                01     02     03     04     05     06
Type     Conc   Qtot   WS     WD     ROOM   RH     BP     AT
Units    mg     m3     Kts    Deg    C      %      "Hg    C
Mult     1.000  3.000  100.0  360.0  080.0  100.0  06.00  100.0
Offset  -0.005  0.000  000.0  000.0 -030.0  000.0  26.00 -050.0

  X4336

*
```

Appendix C (cont.)